INVESTIGATIONS IN THE USE OF COLOR PHOTOGRAPHY FOR GEOLOGIC PURPOSES

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INVESTIGATIONS IN THE USE OF COLOR PHOTOGRAPHY
FOR GEOLOGIC PURPOSES*

by

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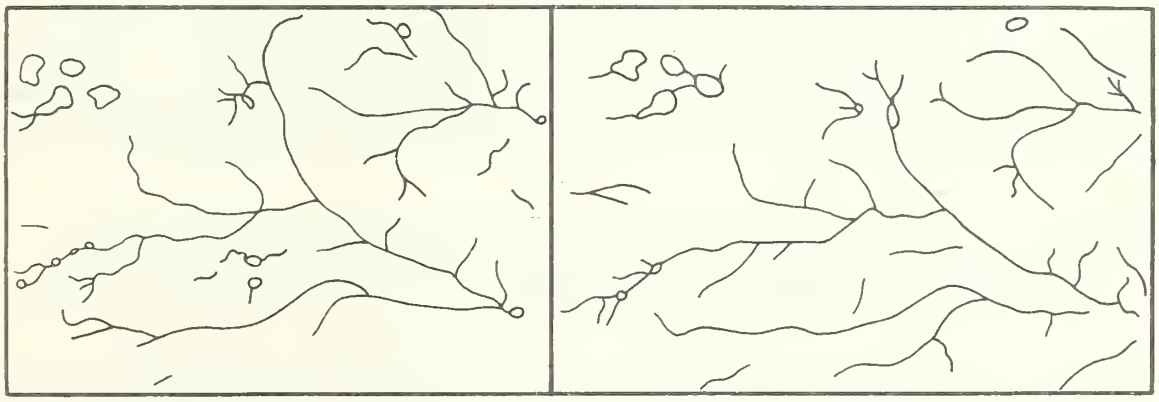
Color photography has many geologic applications, but the solution of some types of interpretive problems is more likely to be aided by the use of color photography than is the solution of others. The solution of interpretive problems that largely relate to landform analysis or problems wherein topographic position is the paramount recognition element, as for example, in mapping the distribution of small streams, is not likely to be facilitated appreciably by the use of color photography. Conversely, interpretive problems involving variations in the color, or pattern or texture (to which color contributes significantly) of the surface are likely to be greatly facilitated by use of color photography. Figures 1 and 2 contrast the total lengths of streams and roads that can be mapped from comparable color and black-and-white



(A) (B)

FIGURE 1

The total length of streams that could be mapped from conventional black-and-white photography (A) and color photography (B) in the same area in east-central New Mexico. Original scale of black-and-white photography is approximately 1:32,000; original scale of color photography is approximately 1:22,000.

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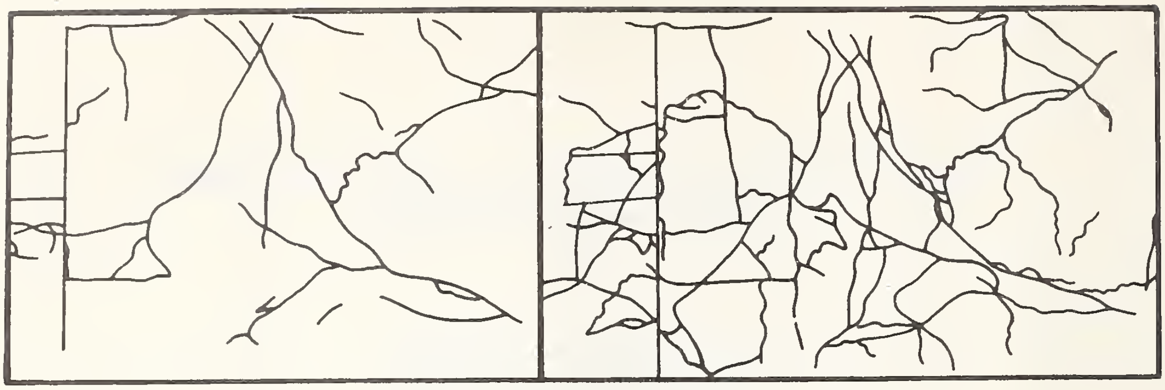

FIGURE 2

The total length of roads and trails that could be mapped from conventional black-and-white photography (A) and color photography (B) of the same area in east-central New Mexico shown in Figure 1.

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photography in a small area in east-central New Mexico. There is little difference in the number or length of streams that could be recognized on the two kinds of photography. The roads, however, are recognizable by virtue of their contrast in texture and possibly color from their surroundings and thus a much greater number of roads are visible on the color photograph than on the black-and-white photograph.

In addition to its demonstrated usefulness in a conventional interpretive sense, color photography has great potential value as an intermediate product in the preparation of specially designed black-and-white photography and as a source of quantitative geologic information. There are many methods of color measurement and many applications of such measurements to geologic study. Three such techniques and applications are discussed in outline form:

1. PROBLEM: To facilitate mapping of the distribution of rock units, in this example the Bernal and San Andres Formations in an area in east-central New Mexico.

   SETTING: The Bernal Formation, a thin reddish colored siltstone overlies gray limestone of the San Andres. Field mapping by ground methods alone would be time consuming because Bernal occupies much of the topographic surface and the surface is dissected and uneven relative to the thickness of the Bernal Formation. The rocks of the two formations are not separable on conventional black-and-white photographs (Figure 3), and their distribution is difficult to map from the color photographs.

PROCEDURE: a. Samples of rock believed representative of the colors of the formations are collected in the field.

b. Color of rock samples are determined by colorimeter analysis (Figure 4).

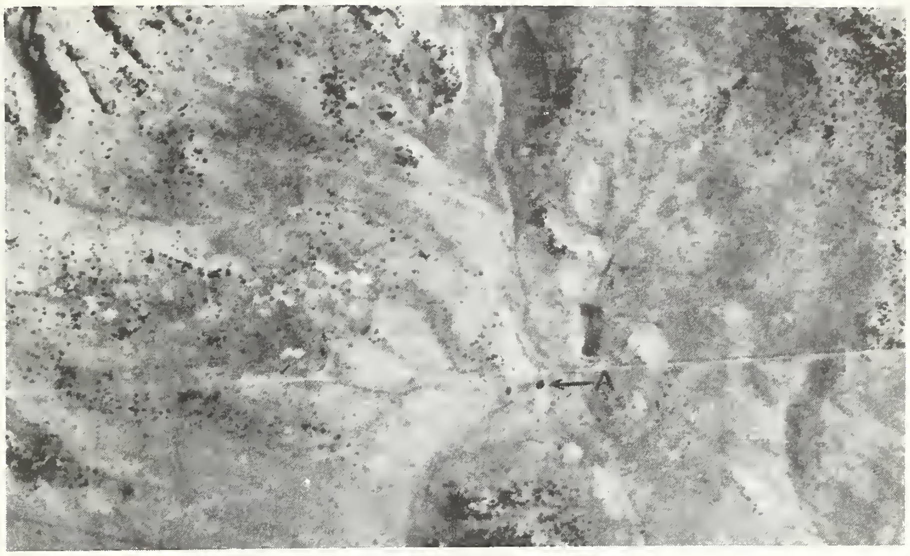

FIGURE 3

Conventional black-and-white photograph of an area in east-central New Mexico underlain by gray limestones of the San Andres Limestone and red siltstones of the Bernal Formation. Point "A" shows the location of ground photograph (Figure 6).

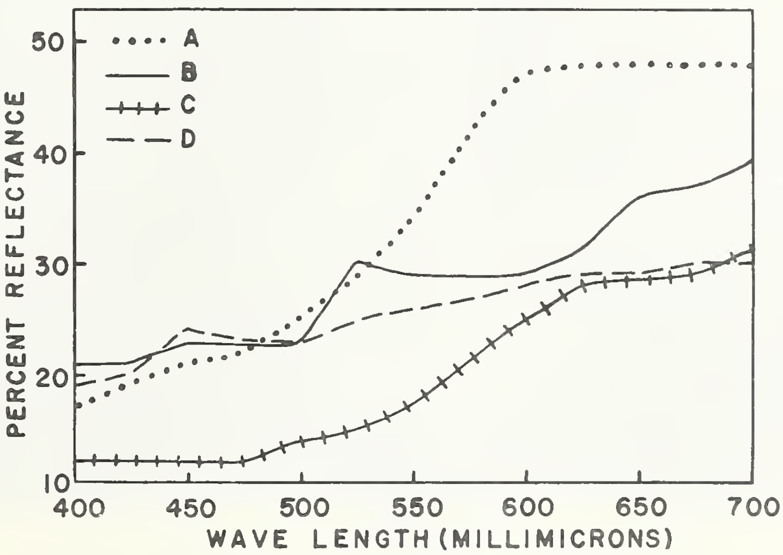

FIGURE 4

Spectral reflectance curves of fresh samples of Glorieta Sandstone (light-brown sandstone) (A); San Andres Limestone (gray limestone) (B); Bernal Formation (red, shaley siltstone) (C); and Dockum Formation (gray sandstone) (D).

c. Color measurements are contrasted to determine the part of the spectrum wherein the greatest difference in total reflection of light occurs (in this example the greatest difference between the light reflected from the Bernal and San Andres Formations (units B and C in Figure 4) is in the 450-520 millimicron part of the spectrum).

d. Photographs of rock samples are taken using panchromatic film and filters (wratten filters numbers 47 and 8) that permit the passage of light in only the 460-520 millimicron part of the spectrum (Ray and Fischer, 1960, page 147, Figure 5; Fischer, 1960, page 138, Figure 61.2). The resultant photographs showed marked tone contrast between the samples and verified the significance of the color measurements.

e. Black-and-white copy of the color photograph of area is prepared using panchromatic film and the same filter combination used in step "d".

RESULT: The resultant black-and-white copy of the color photograph (Figure 5) shows sharp tone contrast between rocks of the two formations. Figure 6 is a close-up view of point A on Figures 3 and 5 and shows that a small amount of exposed rock will present a sharp tone contrast on properly designed photographs.

FIGURE 5

Part of an ektachrome transparency photographed through filters that pass only light in the 460-520 millimicron part of the spectrum. The dark gray areas are underlain by siltstone of the Bernal Formation; the light gray areas are underlain by the San Andres Limestone. Point "A" shows the location on ground photograph (Figure 6).

FIGURE 6

Close-up view of point "A" on Figures 3 and 5. Boulders are of the San Andres Limestone.

CONCLUSION: The distribution of the Bernal Formation on the surface of the San Andres Limestone can be more easily and more accurately mapped from specially prepared black-and-white photographs than from the color or conventional black-and-white photographs or by field methods. Variations in the photographic tone associated with the Bernal Formation (Figure 5) may be related to the thickness of the formation and thus could be measured with a densitometer.

2. PROBLEM: 1. To map the distribution of rock units, in this example the Glorieta Sandstone and the San Andres Limestone in an area in east-central New Mexico, and

2. to assess possible relationships between color and structural setting.

SETTING: The Glorieta Sandstone is overlain by limestones of the San Andres. The topography is typical of much of the mesa-canyon country of the southwestern United States; most of the mesas in this area are capped with limestone. The contact between the sandstone and limestone is irregular as a result of local

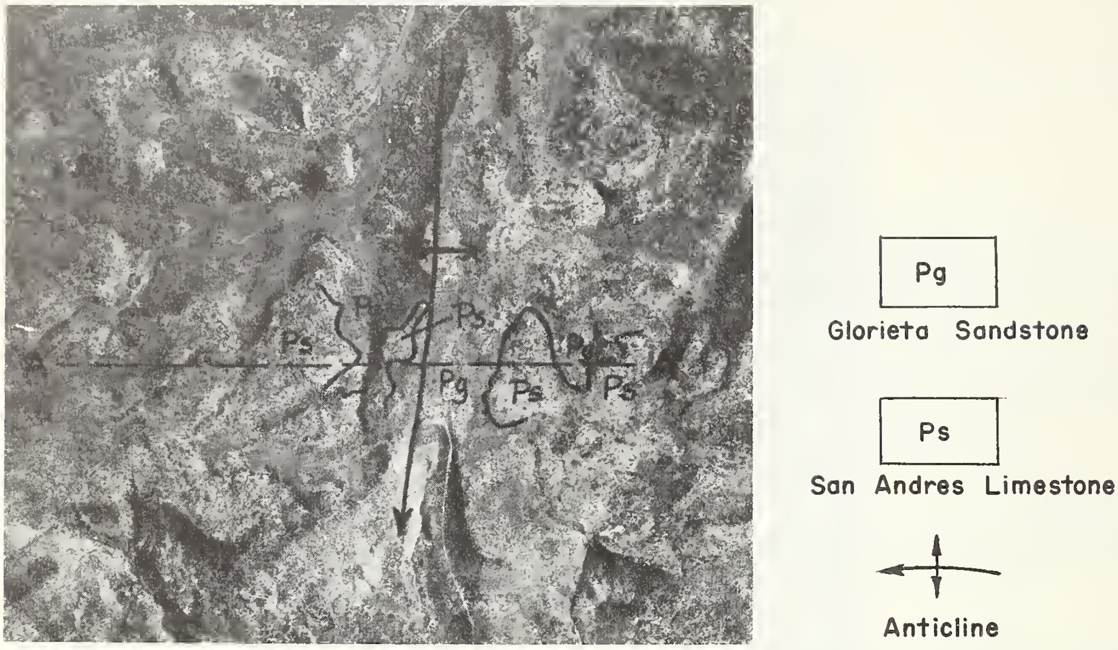

FIGURE 7
Black-and-white photograph showing area in east-central New Mexico underlain by Glorieta Sandstone and the San Andres Limestone of Permian Age. The line A-A' marks the location of a color densitometer traverse.

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solution and subsidence. The two formations are difficult to distinguish on conventional black-and-white photographs (Figure 7) and on color photography. The distribution of the two units can be readily mapped by conventional field methods.

PROCEDURE: a. Rock samples were selected that were believed to be representative of the colors of the two rock units (unit A and B Figure 4). The colors of the rocks were measured with a colorimeter; results suggested that the sandstone reflected more red light than the limestone. Test photographs of the samples made with panchromatic film and a filter that passed only red light (Ray and Fischer, 1960, page 147, Figure 6; Fischer, 1960, page 138, Figure 61.3) confirmed this difference in total reflectance of red light.

b. Three identical traverses were made across color transparency of the area with a color densitometer. The amount of red, green, and blue light passing through the transparency was recorded separately.

c. The records of the amount of red, blue, and green light passing through the transparency along the line of traverse were superimposed (Figure 8).

d. To assess possible color-structure relationships, a series of measurements of the divergence of the red and blue records was made along those parts of the traverse that were underlain by sandstone. Using arbitrary units, the percent difference between the two records was computed and plotted at numerous points along the original traverse line (Figure 9).

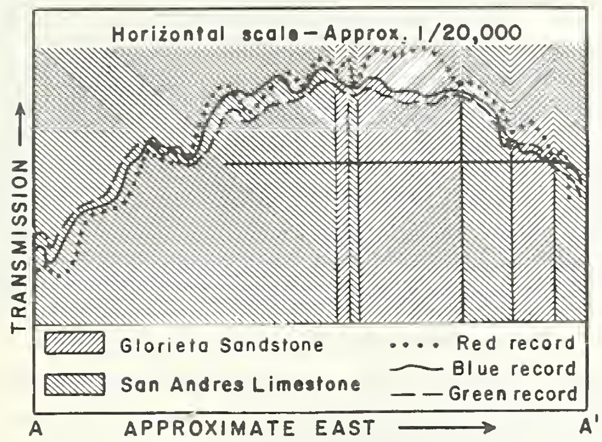

FIGURE 8

Chart showing the relative amounts of red, blue, and green light passing through a color transparency along the line A-A' shown in Figure 7. The broad curve of the lines represent the general light distribution characteristics of the lens in the taking camera.

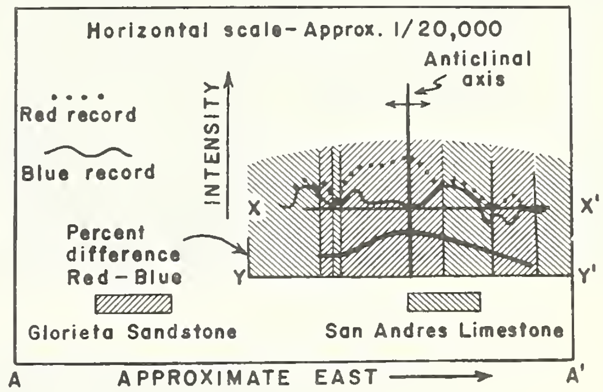

FIGURE 9

Chart showing relative amounts of red and blue light passing through a color transparency along part of line A-A' shown in Figure 7. Relative amounts of red and blue light referenced to a fixed transmission value (X-X'); relative amounts of red and blue light measured in arbitrary units, expressed as percent difference, and referenced to the position of the axis of an anticline (Y-Y').

RESULTS: Areas underlain by sandstone were marked on the combined color record (Figure 8) by a sharp increase in the amount of red light that passed through the color transparency and a related decrease in the amount of blue light that passed through the transparency. An anticlinal axis crosses the line of traverse striking in a direction approximately normal to the direction of traverse. The percent difference between red and blue light increased along the traverse in the direction of the axis and was greatest at the axis (Figure 9).

CONCLUSIONS: The positions of the contact between the Glorieta Sandstone and the San Andres Limestone along the line of traverse can be determined by measuring the relative amounts of red and blue light transmitted through a color transparency.

The sandstones near the axis of the anticline traversed by the color densitometer reflect more red light than sandstones on the flanks of the structure. This may relate to a local depression of the water table and consequent greater oxidation of the iron-rich sandstones. This suggests a method of structural study of special value in areas of poor outcrop.

3. PROBLEM: To map the distribution of rocks that had been subjected to hydrothermal alteration in an area near Goldfield, Nevada.

SETTING: The area is underlain primarily by a sequence of Tertiary volcanic rocks; many of the rocks have been subjected to hydrothermal alteration. Field investigations, related studies of the color photography, and related petrographic studies disclosed that (1) the lithology of relatively unaltered rocks in this area could be recognized by color on color photographs, (2) the original lithology of highly altered rocks could not be recognized by color on the color photographs but the degree of alteration could be ascertained. The more highly the rocks were altered, the more red they appeared to be.

PROCEDURE: a. Color measurements were made from color transparencies of areas of known lithology and alteration. These measurements showed that the highly altered rocks reflected less blue light than the unaltered rocks.

b. Because the highly altered rocks reflected approximately the same amount of red light as some bright unaltered rocks but much less blue light, a black-and-white copy of the color photograph was made using panchromatic film and a filter that passed only blue light.

c. A film positive was made from the resultant negative and through the cooperation of the United States Naval Photographic Interpretation Center placed in an RCA image enhancement device. (This device permits enhancement of minor tone differences and outlines electronically all parts of photograph having the same tone value).

RESULTS: The photograph placed in the image enhancing device was observed and rephotographed at three settings. At the first, setting areas believed to be the most intensely altered (the darkest gray tones) were outlined electronically (Figure 10A). At

the second setting (Figure 10B), rocks believed to be in intermediate stage of alteration (intermediate tones) were outlined.

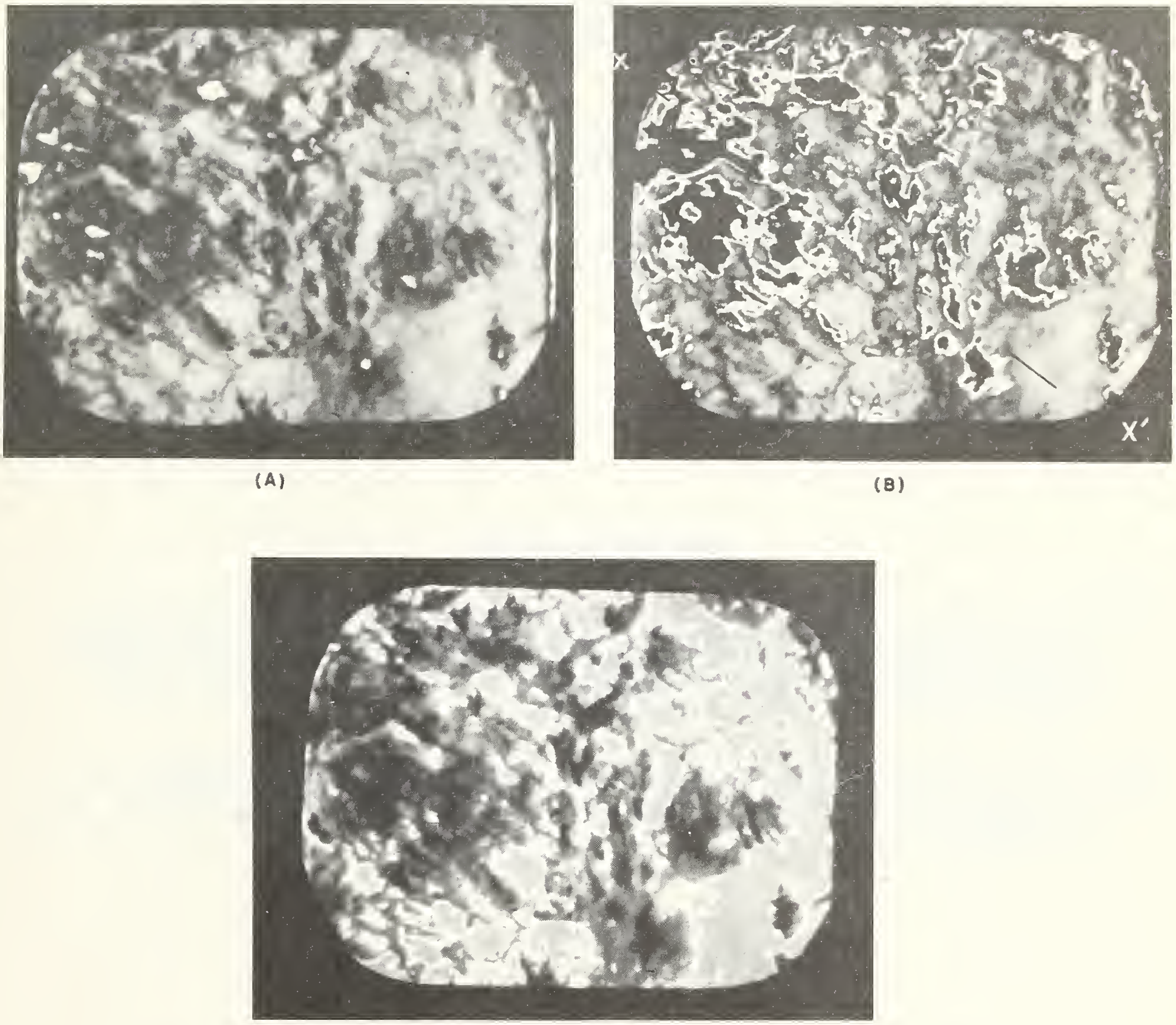

FIGURE 10

Photographs of image on display tube of image enhancement device. Electronic outlines show areas of approximately equal tone value. (A) Areas of dark gray tone (greatest alteration); (B) areas of intermediate gray tone (intermediate alteration); and (C) areas of light gray tone (little alteration). Alignments of some outlines such as those along X-X' in Figure 10B, suggests association of structural elements with pattern of alteration. Photographs through cooperation of the U. S. Naval Photo Interpretation Center.

Alignments of some of the outlines, such as that shown by X-X' on Figure 10B, suggests association of linear structural elements (probably faults) with the pattern of alteration. At the third setting (Figure 10C), rocks believed to be relatively unaltered (lightest gray tones) were outlined. Because the photograph includes some areas not visited in the field the results of this experiment cannot be considered fully verified.

CONCLUSIONS: Subtle color differences on color photographs can be enhanced by printing specially designed black-and-white copies and employing image enhancement techniques for viewing the black-and-white duplicate. Parts of the original photograph having similar color characteristics can be outlined electronically.

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